

BRAC Climate Science Report Overview

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Report Overview

- Prepared by 8 member science panel
- Summarizes scientific consensus
- Uncertainty and confidence addressed using established guidelines
 - Based on quantitative analysis an/or expert judgment
- Content based largely on outline provided by BRAC
- No policy recommendations

Science Team

- University of Utah Department of Meteorology
 - Drs. Tim Garrett, John Horel, Thomas Reichler, Jim Steenburgh
- University of Utah Department of Biology
 - Dr. David Bowling
- Utah Climate Center/Utah State University
 - Dr. Robert Gillies
- Brigham Young University Department of Electrical Engineering
 - Dr. David Long
- USDA/Utah Snow Survey
 - Randy Julander



Uncertainty Scale

- | | |
|--------------------------|-------------------|
| ■ Virtually certain | > 99% probability |
| ■ Very likely | > 90% |
| ■ Likely | > 66% |
| ■ About as likely as not | 33-66% |
| ■ Unlikely | < 33% |
| ■ Very unlikely | < 10% |
| ■ Exceptionally unlikely | < 1% |

Confidence Scale

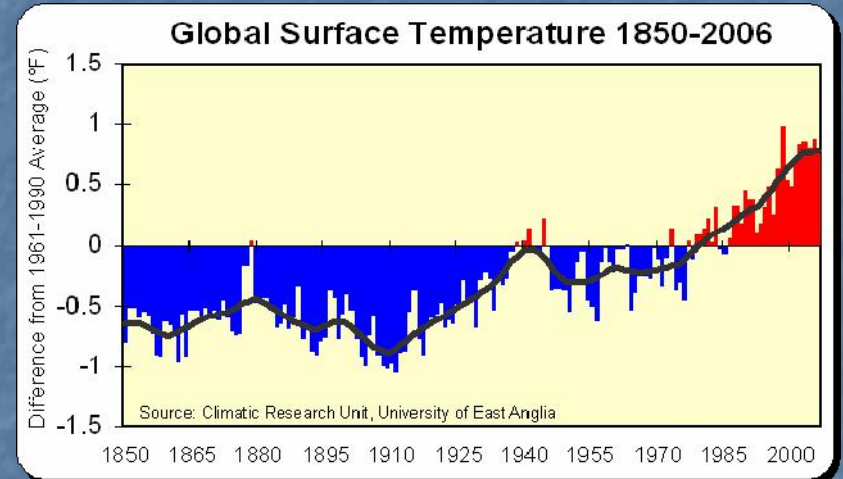
- | | |
|------------------------|-------------------|
| ■ Very high confidence | At least 9 in 10 |
| ■ High confidence | 8 in 10 |
| ■ Medium confidence | 5 in 10 |
| ■ Low confidence | 2 in 10 |
| ■ Very low confidence | Less than 1 in 10 |

Global Climate Change

- There is no longer any scientific doubt that the Earth's average surface temperature is increasing

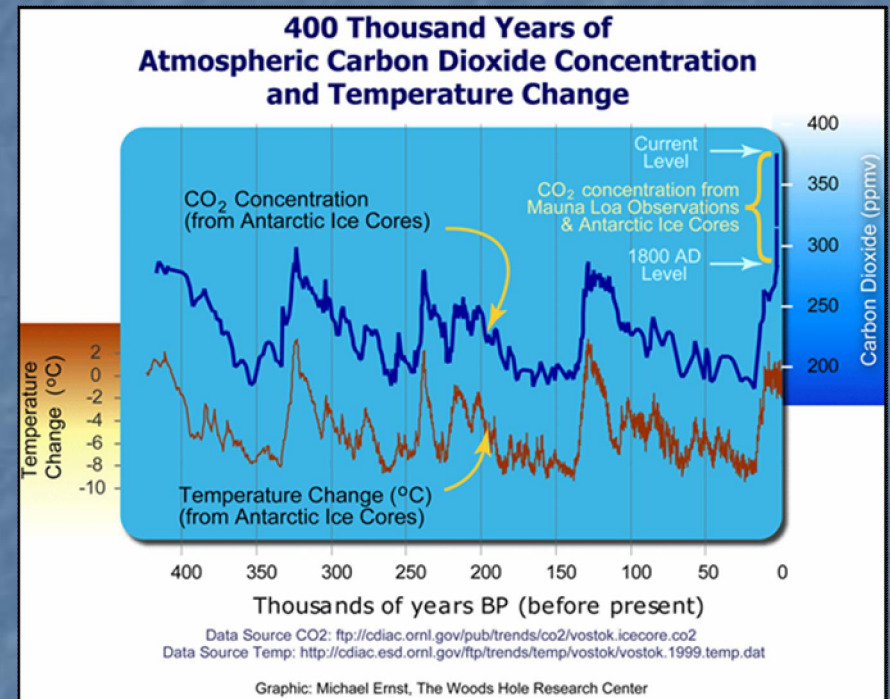
- 1.3°F in last century
- Recent decades warmer than any comparable period in last 400 years (possibly much longer)

- Ocean temperature, ice and snow cover, and sea level changes consistent with this global warming
 - Sea level up 7 inches in 20th century



Greenhouse Gas Concentrations

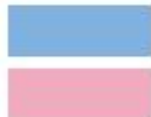
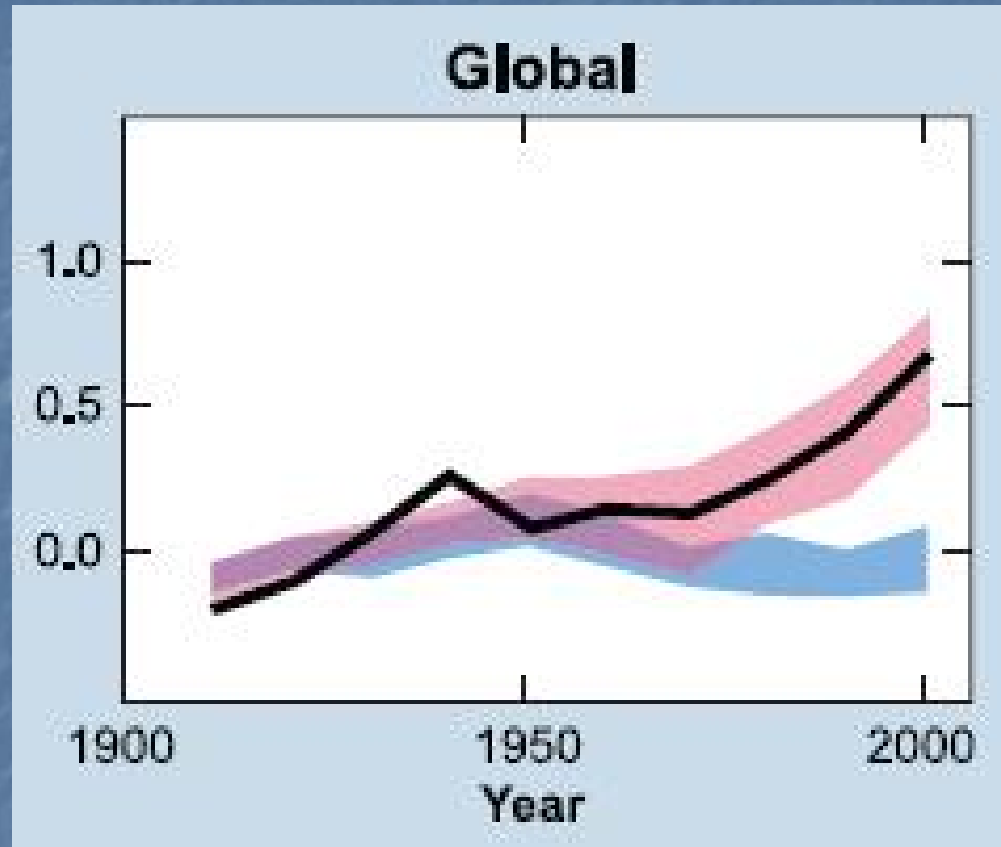
- Carbon dioxide concentrations (381 ppm) are now more than 35% higher than pre-industrial levels (280 ppm)
- Very likely exceeds the highest natural concentrations over at least the last several hundred thousand years



Causes of Recent Climate Change

- There is very high confidence that human-generated increases in greenhouse gas concentrations are responsible for most of the global warming observed during the past 50 years
- It is very unlikely that natural climate variations alone, such as changes in the brightness of the sun, have produced this recent warming

Causes of climate change



models using only natural forcings

models using both natural and anthropogenic forcings

— observations

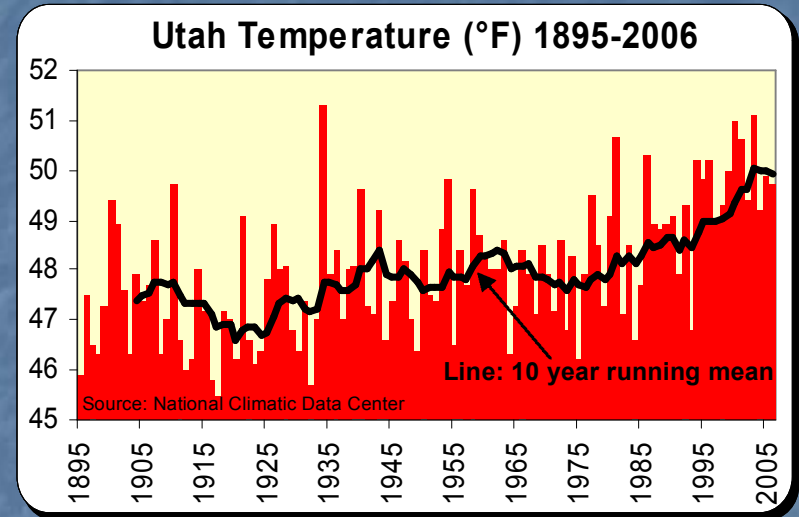
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Western US Climate Change

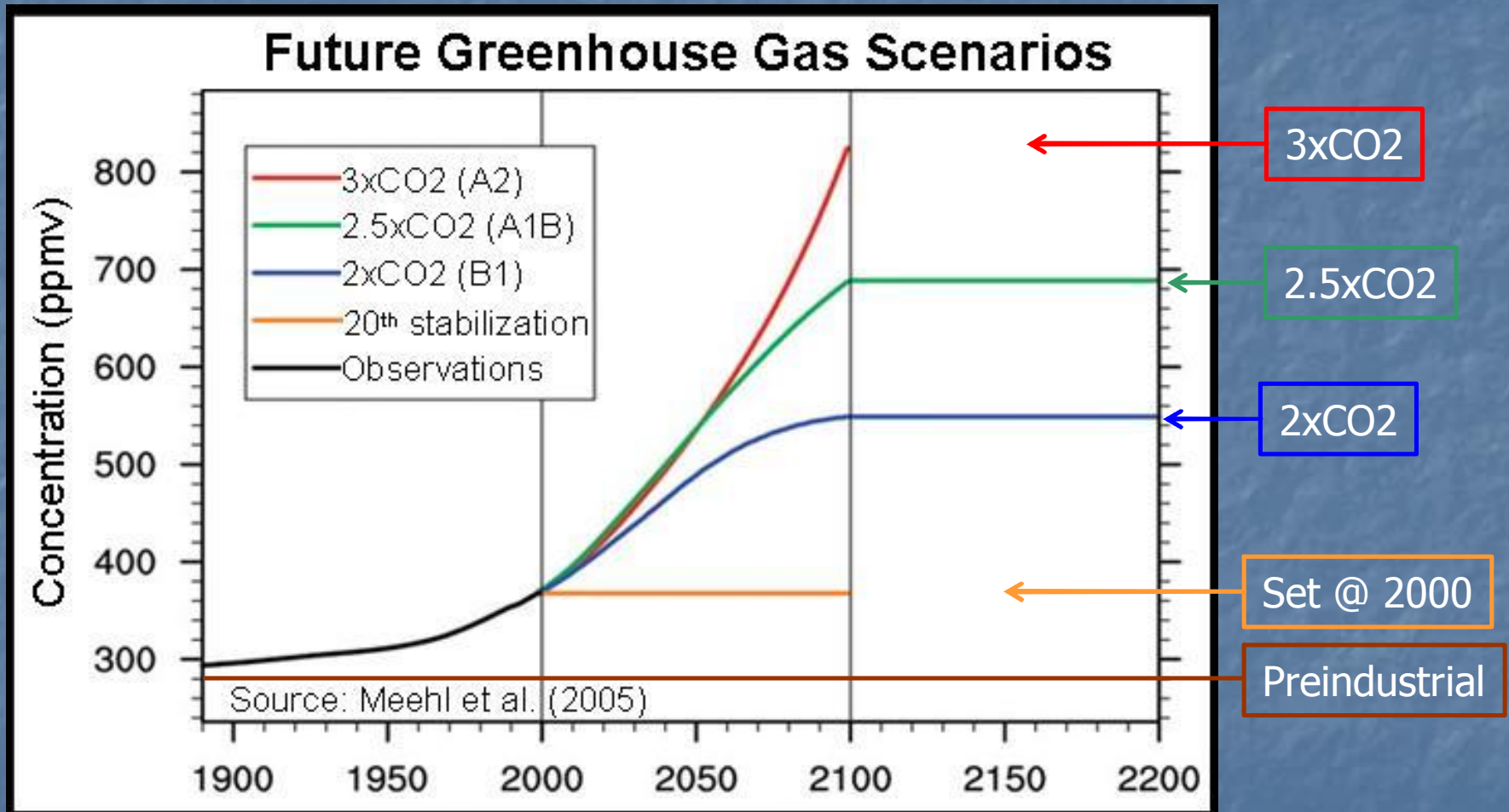
- Most of the western US is warming faster than the global average
- Other climate trends across most of the Western US in the past 50 years include
 - Longer frost-free growing season
 - Earlier and warmer spring
 - Earlier flower blooms and leaf out for several plant species
 - Earlier spring snowmelt and runoff
 - Greater fraction of spring precipitation falling as rain instead of snow

Utah Climate Change

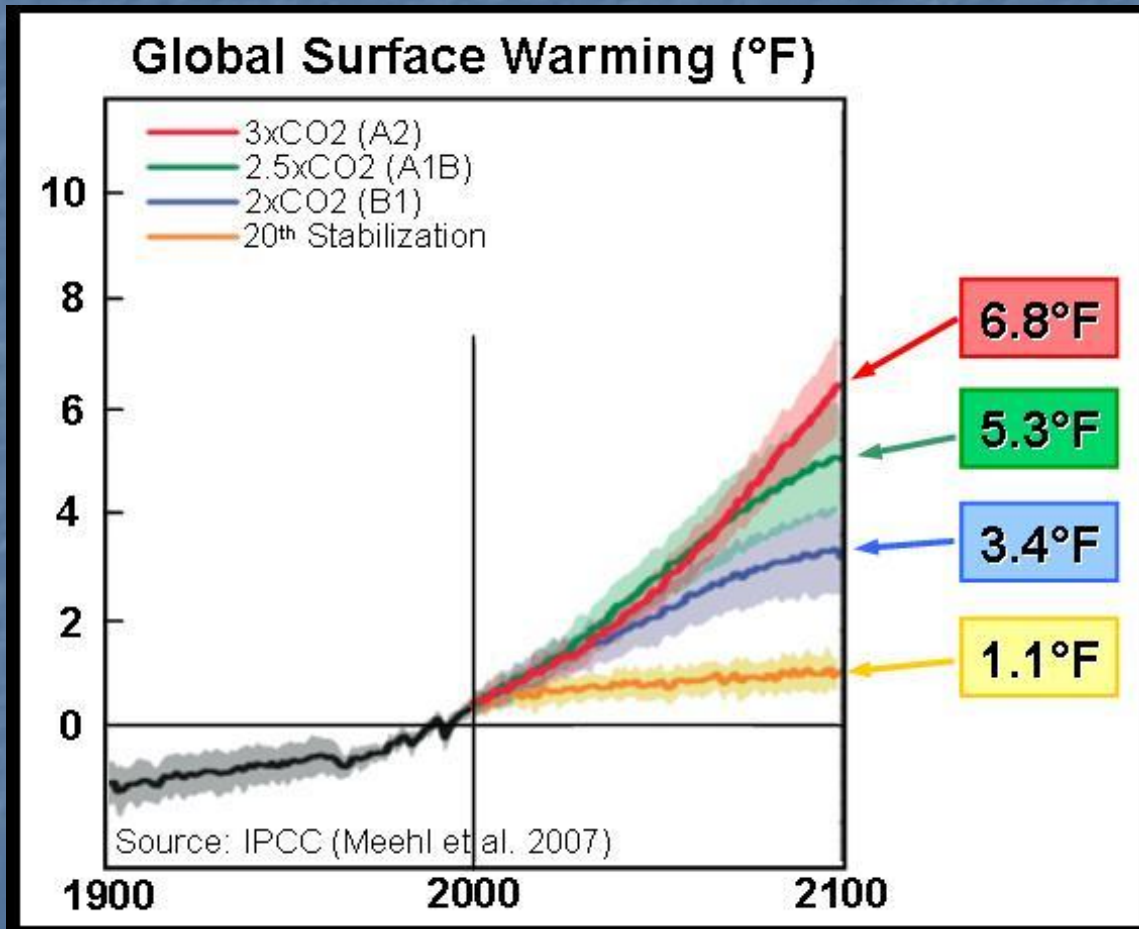
- Last decade was 2°F warmer than the 100 year average
- Snow surveys show no clear long-term (80 year) trend in mountain snowpack
- There is no clear linkage between recent global warming and precipitation within the basin of the Great Salt Lake



Climate Model Scenarios



Climate Model Projections



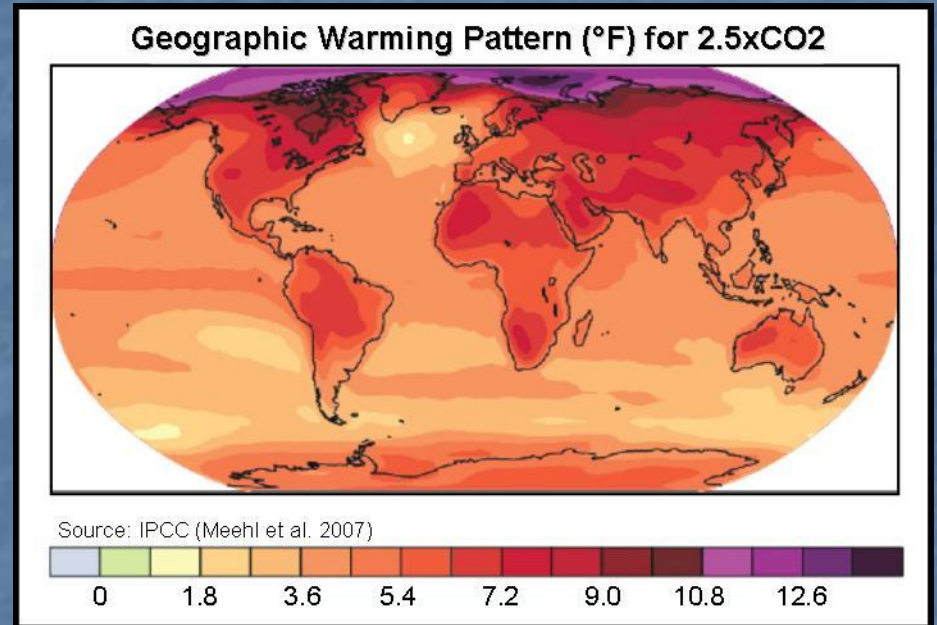
Climate Commitment

Continued climate change will take place over the next several decades as a result of prior greenhouse gas emissions

Ongoing greenhouse gas emissions at or above current levels will very likely produce global temperature, sea level, and snow and ice changes greater than those observed during the 20th century

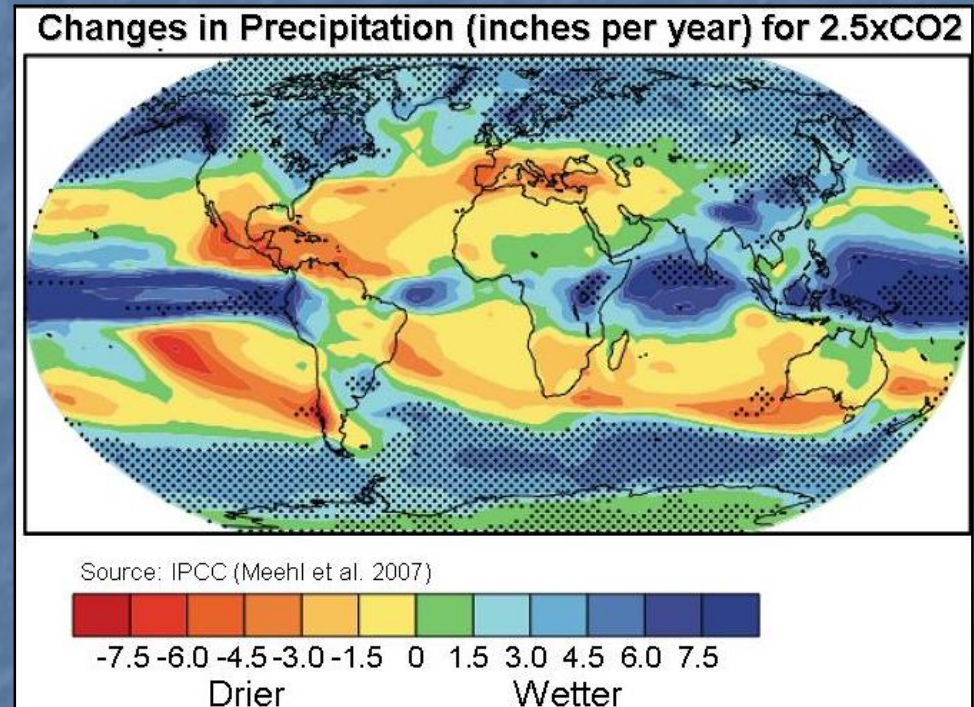
Projected Temperature Change

- Greater warming
 - In the Arctic
 - Over land than ocean
 - In winter than summer
- *It is likely that Utah will warm more than the global average*
- Projected warming for Utah (2.5xCO₂ scenario) is 8°F by 2100
 - Comparable to the present difference in annual mean temperature between Park City (44°F) and Salt Lake City (52°F)



Projected Precipitation Changes

- Less confidence in precipitation projections
- Mid and high latitudes wetter
- Most of subtropics drier
- Utah in the transition zone



Projected Sea Level Change

- It is likely that sea level will continue to rise at rates at or above those observed in the 20th century
 - Models project 7-23 inches by 2100 based only on thermal expansion
 - Shrinking of Greenland/Antarctic ice sheets a wildcard

Catastrophic Climate Change

- There is no universally accepted definition of catastrophic climate change
- We used “abrupt” climate change or a situation where we are committed to a large future rise in sea level
- Consensus has yet to emerge on where the “tipping points” for catastrophic climate change exist
- Identifying these tipping points is an important scientific problem

Utah Snowpack and Runoff

- Ongoing greenhouse gas emissions at or above current levels will likely result in a decline in Utah's mountain snowpack and associated changes to spring runoff
- Expected trends
 - Reduced natural snowpack and snowfall for the winter recreation industry in the early and late winter
 - Earlier and less intense spring runoff for reservoir recharge
 - Increased demand for agricultural and residential irrigation
 - Warming of lakes and rivers with impacts such as increased algal abundance and upstream shifts of fish habitat

Utah Water Supplies and Drought

- It is more likely than not that water supplies in Utah and the Colorado River Basin will decline during the 21st century
 - More definitive projections not possible at the present time
- The threat of severe and prolonged drought far worse than observed in the 20th century is real and ongoing
 - Megadroughts have occurred in the past

Utah Agriculture

- Based solely on climate change, per-acre crop yields in Utah will likely increase on irrigated fields provided
 - Water remains available for irrigation and
 - Temperatures do not increase beyond crop tolerance levels
- Pasture yields and livestock forage will likely decline on non-irrigated fields

Other Utah Impacts

- Great Salt Lake: Declines in mountain snowpack will likely lead to lower average lake levels and increased average salinity unless average winter precipitation increases dramatically
- Human Health: Increased ground-level ozone concentrations and associated cardio-respiratory disease if non-climatic factors (e.g., emissions) do not change
- Wildfire: In isolation, expected climate change is likely to contribute to drier conditions and increased wildfire intensity

Future Assessments

- Utah lacks a coherent program that integrates scientists and stakeholders to better understand, monitor and assess climate change and its impacts
- We recommend establishing such a program to
 - Identify future economic opportunities
 - Improve mitigation
 - Better inform policy options and their implications for Utah
- Possible sectors of interest
 - Water resources
 - Particularly important given our unique climate
 - Winter recreation industry
 - Agriculture

Final Steps

- Provide comments for readability and clarity
- Report revision by science panel

BRAC Outline

Proposed Outline for Climate Science Report Draft: January 4, 2006

1. Sources to be limited to peer-reviewed scientific publications such as:
 - a. UN Intergovernmental Panel on Climate Change
 - b. National Academy of Science/National Research Council
 - c. *Science* and other peer reviewed science journals
 - d. ~~Few Center on Global Climate Change reports~~
2. Current evidence of climate change, what is known and generally agreed to/where is there is the greatest uncertainty and evidence is disputed:
 - a. Average temperature rise, record high temperatures
 - b. Changes in global ice cover, including Arctic and Antarctic sea ice, Greenland and other land-based ice sheets and glaciers
 - c. Increased frequency and severity of hurricanes
 - d. Changes in species/habitats associated with climate change
 - e. Droughts, rainfall, and other major changes in climate
3. Climate models and projections about future climate change:
 - a. Long-term temperature trends and projections
 - b. Projected changes in ocean temperature, sea level rise, ocean circulation
 - c. Projected changes in global weather, rainfall, and storms
 - d. Impacts on human health, disease
 - e. Impacts on agriculture, soils, food production
 - f. Impacts on biodiversity
 - g. Feedback loops, tipping points, and the threat of catastrophic climate change
4. Specific impacts of climate change on Utah and the West:
 - a. Forest fires, soil, drought, and temperature increases
 - b. Droughts, snowpack, rainfall, and water supply
 - c. ~~Benefits to Utah and the West from preventing disruptive climate change~~

Sources restricted to peer-reviewed scientific articles and panel reports

Added section discussing if climate change is natural or human caused

Added section on recent climate change in Utah

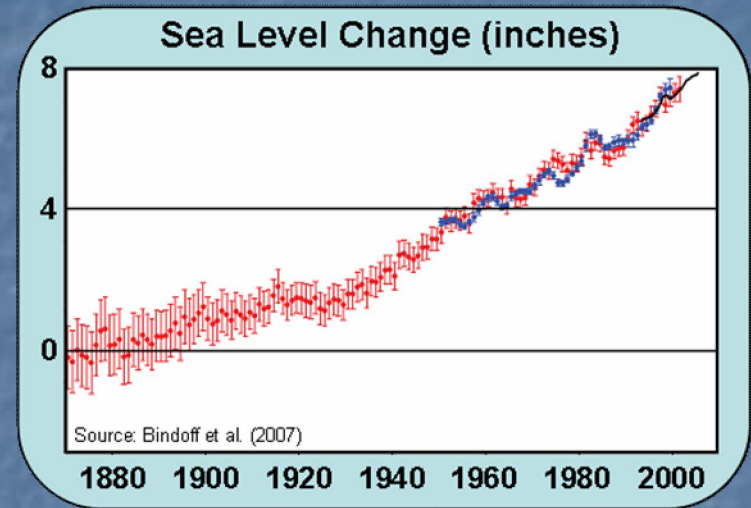
Benefit discussion left to BRAC

Other Projected Impacts

- Negative health effects expected to outweigh positive ones, particularly in developing countries
- Crop productivity will likely increase slightly in mid to high latitudes for local temperature increases of less than 2-5°F
- Crop productivity is projected to decrease in the low latitudes even for small temperature increases
- 20-30% of all known plant and animal species will be more vulnerable to extinction

Other Global Climate Trends

- Mean sea level rose 7 inches in the 20th century
- Shrinkage of mountain glaciers, ice caps, and the Greenland ice sheet responsible for 35-40% of the rise since 1993
- Little or no long term trend in the average number of tropical cyclones per year
- Increasing financial losses from hurricanes due to the ever-growing concentration of population and development in coastal regions



Overview



Species and habitats

- It is very likely that earlier warming in the spring is strongly affecting plants, animals, and insects
 - Earlier greening of grasses and trees, flowering of plants, migration of birds and insects, etc.
- There is very high confidence that the ranges of some plants and animals have moved toward the poles or towards higher elevations

Final Outline

- Executive summary
- Introduction
- Consensus view of global climate change
 - Evidence of a warming Earth
 - Is recent warming natural or human caused?
 - Other recent climate trends
 - Droughts and rainfall
 - Sea level rise
 - Glaciers, ice caps and sheets, and sea ice
 - Hurricanes and tropical cyclones
 - Species and habitats

Final Outline

- Climate change in the Western United States and Utah
- Projections of future climate change
 - Overview of climate models
 - Strengths and limitations of climate models
 - Future greenhouse gas scenarios
 - Projected changes
 - Temperature
 - Rainfall, storms, and weather
 - Sea level
 - Projected impacts
 - Human health and disease
 - Agriculture and food production
 - Biodiversity
 - Feedbacks, tipping points, and catastrophic climate change

Final Outline

- Climate change and impacts on Utah
 - Impacts on snowpack, water supply, and drought potential
 - Impacts on the Great Salt Lake
 - Impacts on agriculture
 - Impacts on human health
 - Impacts on forests, wildlands, and wildfire
 - Impacts on soils
- Improving assessments of climate change impacts
- Appendix A: Team members
- Appendix B: Scientific confidence and uncertainty
- References